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THE INFLUENCE OF SOIL FAUNA ON DECOMPOSITION OF PINE NEEDLE LITTER; A FIELD EXPERIMENT

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THE INFLUENCE OF SOIL FAUNA ON DECOMPOSITION OF PINE NEEDLE LITTER; A FIELD EXPERIMENT

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Abstract

The role of the mites *Phthiracarus* spp. and *Rhysotritia ardua* (Koch) and the enchytraeid worm *Cognettia sphagnetorum* (Vejd.) on Scots pine needle litter decomposition was studied in a field experiment.

Modified litter bags were used to enclose litter and animals. In some cases the needle litter with animals present lost less dry weight during the experiment and had lower content of lignin after the experiment.

This could possibly be interpreted as an effect of selective animal grazing of microorganisms.

1. Introduction

Several authors have reported that the soil fauna will increase the decomposition rate of soil organic matter (eg. Kurcheva 1960, Edwards and Heath 1963, Standen 1978). However, the role of certain animal groups is still under debate.

Decomposition of organic matter in field situations is often studied in different types of litter bag experiments. Litter bags can be chosen with a mesh size that makes the litter accessible only to soil fauna within a certain size range (Edwards and Heath, 1963, Bocock, 1964, Mignolet and Lebrun, 1975). It is also possible to enclose a known quantity of animals with litter and compare the decomposition rate with that in litter in bags without these animals (Standen, 1978). The study presented here is of the latter kind and was carried out within the frame of a survey of the decomposition and mineralization processes in a pine forest soil.

2. Materials and methods

2.1 Site description

The site used for the experiment is a 120-year old Scots pine (*Pinus sylvestris* L.), stand on sediment located at Ivantjärnsheden, Jädraås, in central Sweden ($60^o49'$N, $16^o30'$E, 185 m a.s.l.). The ground is covered by a mosaic of mosses and lichens and the field layer of the vegetation is dominated by heather-, blueberry- and cowberry-shrubs (*Calluna vulgaris*, *Vaccinium myrtillus* and *V. vitis-idaea* resp.) (Bråkenhielm 1974). The soil profile is an iron podsol. The dry weight of the humus layer is ca 2 $kg \cdot m^{-2}$, 77% of which is organic material (Staaf and Berg 1977). Litter decomposition was studied in the humus layer, i.e. about 5 cm deep in the soil.

2.2 Litter

The litter used for the experiment was pine needle litter of two age categories, namely new needle litter, fallen less than half a year before being collected for this experiment, and old needle litter, fallen 1-2 years before the time for collection. Age classification of the needles was based on their colour. The needles were dried to constant weight at room temperature and apportioned into lots of about 0.5 g.

2.3 Fauna

Two kinds of animals were tested separately in the experiment, viz. mites of the families Phthiracaridae and Euphthiracaridae, in the following for simplicity called phthiracarid mites, and the enchytraeid worm *Cognettia sphagnetorum* (Vejd.), which is the dominant soil faunal component in terms of biomass at the actual site (Axelsson et al., 1974). Its feeding preferences are not known in detail but it is known to be a litter and microorganism feeder (Standen and Latter, 1977, Springett and Latter, 1977). The phthiracarid mites were thought to be possible litter feeders as Prusinkiewicz et al. (1975) have shown that *Phthiracarus piger* (Scop.) has bacteria capable of decomposing lignin and cellulose associated with the gut, and as Hayes (1963) has grown phthiracarid mites on decomposing coniferous leaf litter.

The mites used in the experiment were extracted from the soil with Tullgren funnels and the enchytraeids with modified Baermann funnels (O'Connor, 1962). Both extractions were done at the field station on the site.

The relation "number of animals/amount of pine needle litter" in the experiments was chosen to be within an order of magnitude to natural circumstances at the Jädraås site (cf. Staaf and Berg 1977, Axelsson et al. 1974, Persson, 1975).

In the series with phthiracarid mites 10 *Phthiracarus* spp. and 5 *Rhysotritia ardua* (Koch) were added to each 0.5 g portion of needle litter and in the enchytraeid series 15 *C. sphagnetorum* were added.

2.4 Litter chambers

In a pilot study conventional litter bags of tea-bag design were found to be unsuitable as the nylon mesh became electrostatically charged, which made the bag walls stick together with the animals more or less squeezed between them. For the following experiments a new type of litter chamber was constructed. As shown in fig. 1, plexiglass sheets, 10.5 cm x 17 cm x x 0.8 cm, were provided with six holes, one for each treatment, with a bottom and covering of nylon mesh with a mesh size of 25 μm. The litter in the chambers was moistened with water from a humus suspension (1:1 of humus and tap water) before introduction of the animals.

2.5 Experimental periods

The experimental periods and the number of litter chambers in each period are given in fig. 2, where also soil temperature and moisture data are indicated (Jansson, in press). The litter chambers were distributed to randomly selected points at the field site. The treatment of a series of litter chambers, before as well as after the experiment, was completed within two days during which the material was stored at +5^{O}C. Transportation of the litter chambers from the laboratory to the field and vice versa was done in insulated frigolite boxes.

2.6 Analysis

Pine needle dry weight, after 24 hrs. in +85^{O}C, and content of Klason-lignin, analysed according to Bethge et al. (1971), were determined for randomized subsamples of old and new litter before the experiment.

After the experimental period in the field the following analyses were undertaken;

- Respiration was measured with a Gilson respirometer on the litter from 5 x 6 randomized litter chambers per period.
- All litter was examined under stereomicroscope for remaining animals.
- Loss of dry weight of the litter was determined after 24 hrs. in 85°C.
- Analysis of Klason-lignin was done on randomly selected samples (4, 5 and 7 respectively per treatment) from the periods I, III and IV and on all samples from period II.

3. Results

The results of the experiment are summarized in Table 1, where also significant differences according to analysis of variance and LSD-test on the 95% level are indicated (Snedecor & Cochran 1967). Figure 3 gives a picture of dry weight losses and content of Klason-lignin in the litter.

There is no difference in respiration between treatments for any litter or time period. The rate of respiration appears, although it was not tested, to be higher for the old needles. The number of recovered animals varied considerably between samples as regards the enchytraeids, of which only a small proportion usually was recovered. The mites, on the other hand, were recovered to 40% or more.

Dry weight losses (fig. 3) that are significantly different between treatments were found in the first two periods but for different litter series. In period I with new needles all treatments differed from each other with the highest weight loss found with enchytraeids and the lowest with mites. In period II old needles with mites lost less dry weight than the control and enchytraeid treatments. Throughout the experiment the mean values for dry weight loss are generally lower for the mite than for the other treatments.

The amount of lignin in the needles before the experiment was found to be 34% in old needles and 35% in new needles, respectively. According to Berg (1978) one would expect higher percentage content of lignin in old than in new needles. For one age bracket of pine needles at the same locality Berg found an almost linear increase in the percentage of lignin,

from ca 20 to 40%, for the first two years of pine needle decomposition. During the third year the lignin content stayed at the 40% level. However, the variation between years in the initial content of lignin covers the values found here for new and old needle litter (Berg, pers. comm.).

The content of lignin, as percentage of dry weight (fig. 3), after the experiment was significantly higher in the control than in the mite and enchytraeid treatments in the new needle series for periods I and II.

The longer experimental periods, III and IV, showed no significant differences at all between treatments.

4. Discussion

Soil fauna may influence litter decomposition in various ways; directly through consumption of litter or more or less indirectly by affecting the microorganisms involved in decomposition. Thus soil fauna consumes parts of the microorganism population. On the other hand, by producing faecal pellets soil fauna also supplies new substrates to the microorganisms as well as increasing the area available to them.

A direct influence would be reflected as higher dry weight losses in samples with fauna present. Such a higher dry weight loss was found for one of the enchytraeid treatments (I:new). This result is consistent with those of Standen (1978), who found that *Cognettia sphagnetorum* increased dry weight losses of *Eriophorum-*, *Calluna-* and *Sphagnum-*litter. Standen also found that the enchytraeids affected decomposition much less in the winter than in other seasons. Thus the result of the present experiment where no differences were found for the enchytraeid treatment in period II which was dominated by winter, also agrees with Standen's findings.

C. sphagnetorum has been shown to prefer old litter (Standen and Latter, 1977, Latter and Howson, 1978, Lundkvist, unpublished) and certain litter species before others, e.g. *Eriophorum* and *Calluna* before *Sphagnum* (Standen, 1978). Also in the present experiment more enchytraeids were recaptured from old than from new pine needle litter. However, possibly pine needle litter on the whole is not very attractive to the enchytraeids.

For periods III and IV, which both covered the whole summer season, some drawbacks of the litter chamber method probably influenced the result. The enclosed animals had reduced possibilities to avoid summer drought at more protected microsites. Many enchytraeids probably died quite early in the experiment; note the low mean values and high standard errors for recovered worms. Also the mites may have suffered from dry periods and possibly may have become inactive for some time.

The effects of an indirect influence through consumption of microorganisms would be highly dependent on the extent and selectivity of this consumption. Ausmus and Witkamp (1974), from a decomposition experiment, suggest that phthiracarid mites have a stimulating effect on microorganism growth and decomposition by grazing the microorganisms.

The present results point to an opposite effect, namely that the mites have decreased decomposition of the needle litter. The mite treatments showed lower dry weight losses, which indicate that the mites in this experiment had reduced the microorganism activity probably as an effect of consumption of microorganisms.

In an experiment with a collembolan species and two species of fungi, inhabiting litter, Parkinson et al. (1977) have shown that growth and competitive ability of the litter fungi were affected by consumption of the microorganisms by the animals. Interactions of this kind may apply also to the present experiment.

The lower percentage amount of lignin found in two mite (I:new, II:new) and two enchytraeid (I:new, II:new) samples suggests that these animals may have a favourable effect on the lignin decomposing microorganisms. If this is a result of a growth stimulus on the lignin decomposing microorganisms through faunal grazing on the very same population or if it is due to consumption of other sections of the microorganism community which in turn may enhance the competitive ability of the lignin decomposers cannot be decided until the feeding preferences of phthiracarid mites and enchytraeids are better known.

5. Acknowledgements

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Table 1. Surveyed litter decomposition parameters. Results are given from new and old pine needle litter in the control, phthiracarid mite and enchytraeid treatments after the experimental periods I-IV.

Experimental period	Treatment	Remaining animals (out of 15) $\bar{x}$	S.E.	Respiration µl O_2/g DW $\bar{x}$	S.E.	Dry weight loss % of init. DW $\bar{x}$	S.E.	Sign. diff. $p \leq 0.05$	Klason-lignin in % of litter dry weight $\bar{x}$	S.E.	Sign. diff. $p \leq 0.05$
					(n=5)		(n=10)			(n=4)	
I	new-contr.			110	4	13.0	0.5		35.7	0.8	
	new-phthir.	11.6	0.6	115	2	11.8	0.3		33.0	0.2	
	new-ench.	3.7	0.6	118	3	14.1	0.4		33.3	0.4	
					(n=5)		(n=10)			(n=4)	
	old-contr.			121	4	13.9	0.5		35.7	0.6	
	old-phthir.	11.0	0.9	125	2	13.6	0.6		37.1	0.5	
	old-ench.	6.3	1.0	125	3	13.5	0.3		35.8	0.7	
					(n=5)		(n=10)			(n=10)	
II	new-contr.			134	6	27.2	0.8		40.6	0.3	
	new-phthir.	7.5	0.7	127	14	26.0	1.1		37.5	0.5	
	new-ench.	0.4	0.2	120	16	27.0	0.5		37.7	0.5	
					(n=5)		(n%10)			(n=10)	
	old-contr.			129	9	25.4	0.5		40.1	0.5	
	old-phthir	8.2	0.6	99	21	22.4	1.2		39.9	0.5	
	old-ench.	1.0	0.5	137	11	25.9	0.8		40.0	0.5	
					(n=5)		(n=10)			(n=5)	
III	new-contr.			73	9	34.5	1.0		51.9	1.7	
	new-phthir	7.1	0.7	72	13	32.7	1.1		48.8	0.9	
	new-ench.	0.2	0.1	68	12	34.1	1.1		50.1	1.0	
					(n=5)		(n=10)			(n=5)	
	old-contr.			95	22	30.9	1.0		49.5	0.9	
	old-phthir.	6.5	0.8	70	9	29.0	1.3		50.5	0.8	
	old-ench.	2.5	1.8	100	18	30.8	0.7		49.4	0.5	
							(n=15)			(n=7)	
IV	new-contr.					38.6	1.6		47.7	0.3	
	new-phthir.	7.4	0.6			40.2	0.7		48.7	0.4	
	new-ench.	0.1	0.1			39.8	0.8		48.2	0.7	
							(n=15)				
	old-contr.					37.3	1.3		48.3	0.6	
	old-phthir	7.8	0.5			37.2	0.9		49.2	0.5	
	old-ench.	3.8	2.6			38.6	1.4		49.6	0.6	

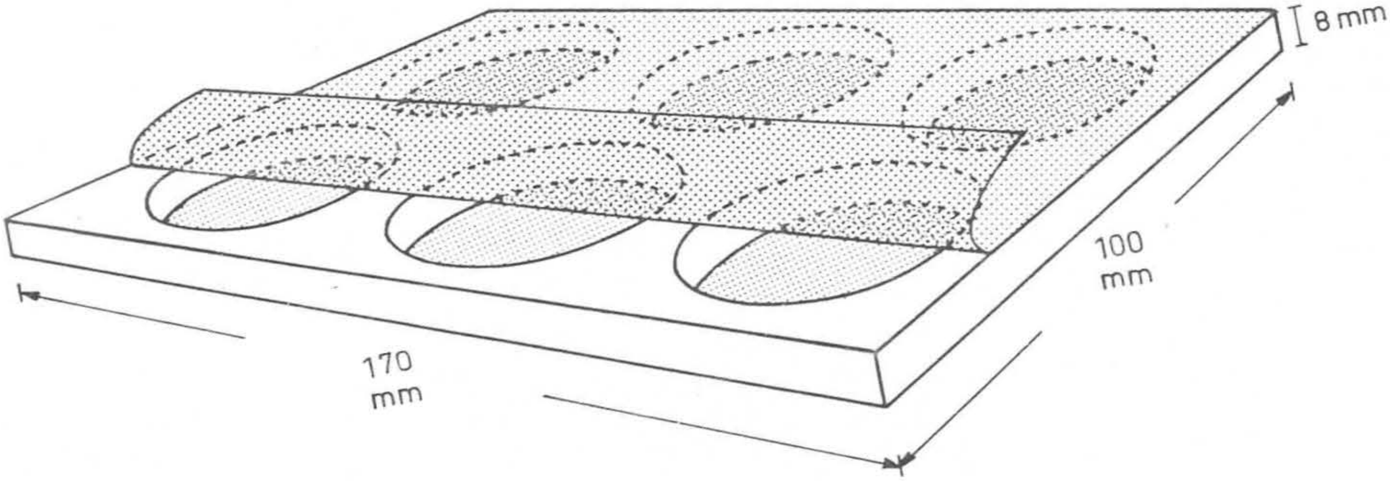

Figure 1. Setup of litter chambers used in the experiment.

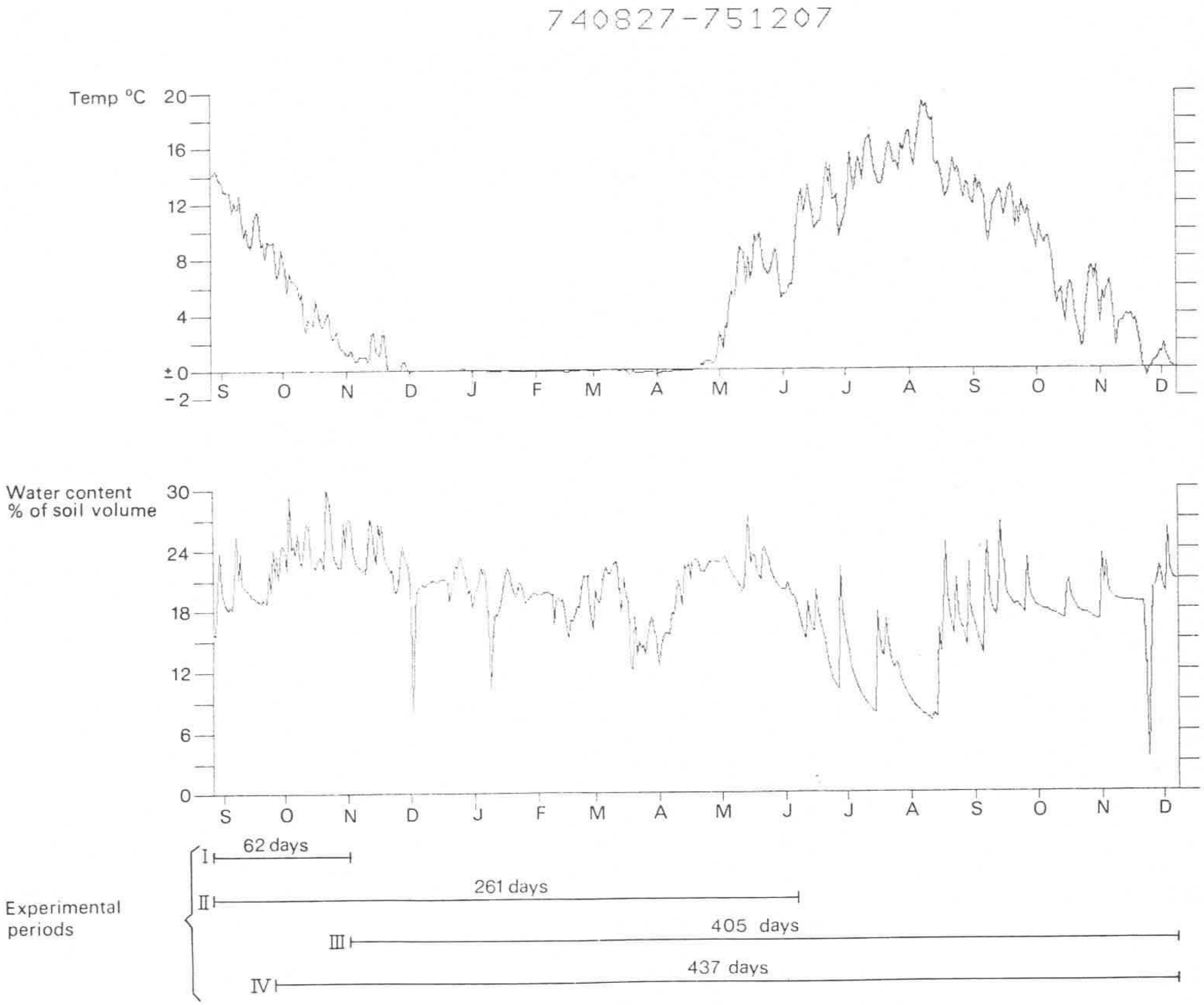

Figure 2. Soil temperature, water content of soil in percent and experimental periods. N.B. The low water content in the winter months are due to ice formation, only fluid water being included in the figures.

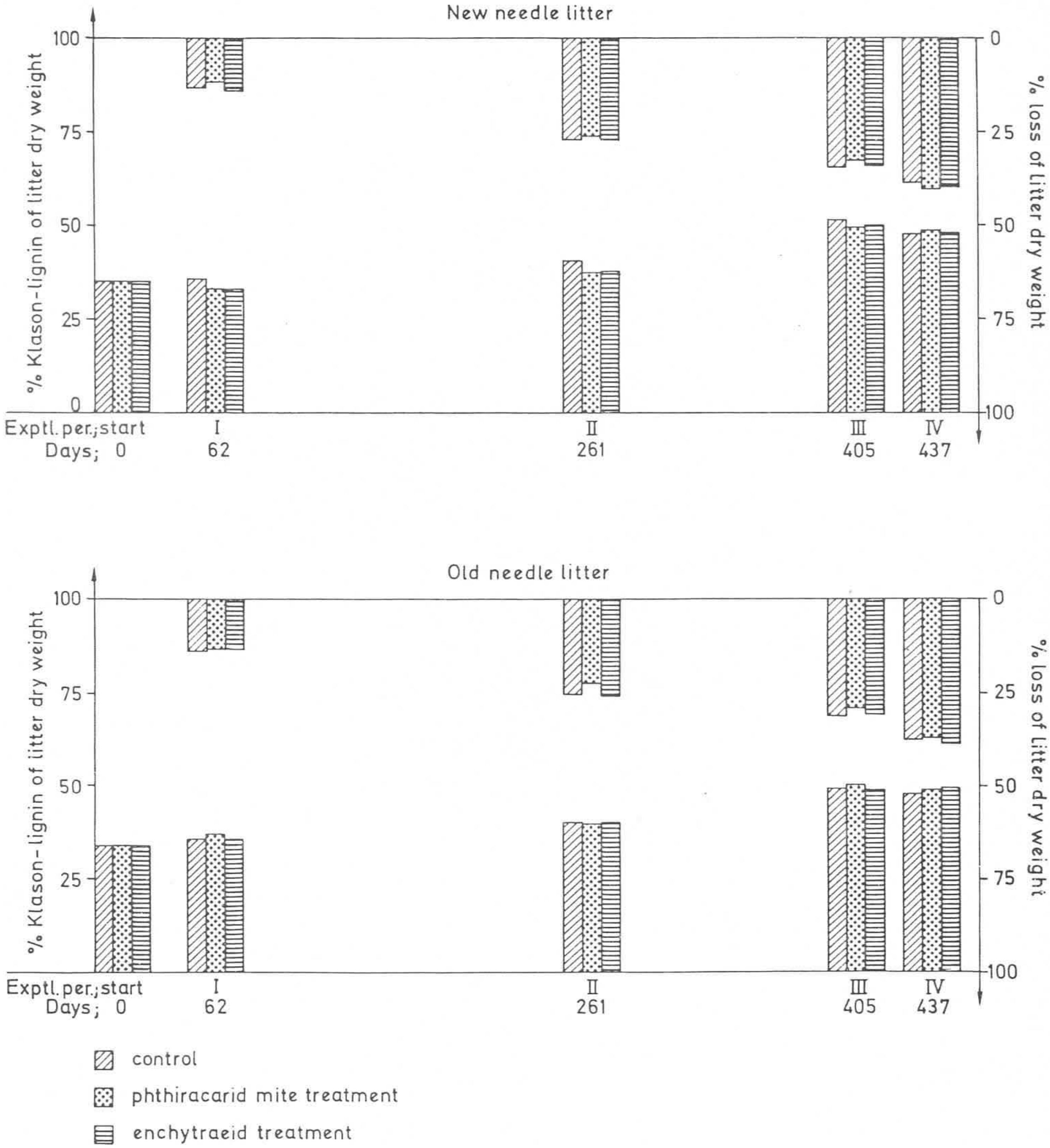

Figure 3. Percentage loss of litter dry weight (hanging columns, right ordinates) and percentage content of Klason-lignin in the litter (standing columns, left ordinates) for new and old litter after different experimental periods.